

the contacts to have been made too *close* by the quantity  $0''.273$  (Wt. 11), the observed semidiameter being too small by that amount. The final result shows unmistakeably that the effect of the cloud through which this set was observed had been to cut off the sharp cusp altogether, and to reduce the planet more or less to the oblong figure artificially produced by Mr. Christie.

In the paper to which I have already referred (*Monthly Notices*, vol. xxxiii. p. 562), I have stated that there can be little doubt that the amount of irradiation of the disk of *Venus* varies from day to day with the transparency of the atmosphere. I have only to add, that the preceding observations prove beyond question that such changes occur at much smaller intervals, and that near the hour of sunrise or sunset are of such magnitude as to require careful elimination in all observations of accuracy. Finally, we may conclude that for the determination of solar parallax by the method suggested by MM. Krüger and Dunkin, each limb of the planet will require to be observed simultaneously or nearly so, in order to evade this peculiarity; and that had this been provided for at both northern and southern stations a valuable result would most probably have been obtained.

*Orwell Park Observatory,*  
1876, December 12.

### *Observations of Shooting Stars, April to December, 1876.*

By W. F. Denning, Esq., F.M.S.

(Communicated by the Rev. R. Main, M.A., F.R.S.)

The following list of 51 radiant-points were deduced from the paths of 766 shooting stars observed and registered at Bristol during the nine months, April to December, 1876. About 1,050 were seen altogether within this period, but some of them (including a number of Perseids, Geminids, etc.) were not recorded, as their radiants had already been indicated with sufficient accuracy from other paths; and the remainder were not well seen, and accordingly had to be rejected. Previously to October my observations were made irregularly, and not often continued for long periods, but during the last three months of the year the sky was watched on every fine night for several hours, generally before midnight. This will account for my having seen many more meteors in the autumnal months than in the spring and summer. In October, November, and December, during watches amounting in the aggregate to  $69\frac{1}{2}$  hours, 532 meteors were seen, and 447 of them registered. Of the total number observed, 322 were noted in 49 hours' watching before midnight, and 210 of them in  $20\frac{1}{2}$  hours after midnight (chiefly between 3 and 6 A.M.), so that the rate of frequency A.M. greatly exceeded that P.M., and this was especially marked in November. During the preceding months I did very little work

A.M., and have no data to make the same comparison. The chief showers of the period under review were the Perseids (August 10), the Geminids (December 12), the Cassiopeids (July–August), the Draconids (July–August), the Muscids (October 15), the Taurids I. (November 8), the Taurids II. (December 6), the Aurigids (November and December 13), the Leonids minor (November 25–28), etc. About 40 of the positions included in the list are redeterminations of showers already known or suspected, and in regard to the latter these confirmations will be useful. The remainder appear to be new, and were principally observed in the mornings of November and December, and one of them (a bright and somewhat active display of slow meteors) was seen in the evenings—notably on December 6, when it supplied nearly one-half of the visible shooting stars, as did the Geminids on the night of December 12. A feeble and very late return of the Leonids was observed on the nights of November 19–20 (or A.M. 20–21), but cloudy weather had prevented a look-out on the few preceding nights. From the same cause the Lyraids (April 19–20) entirely eluded me. The Orionids (October 17–19) appear this year to have been but feebly shown, and I saw few of them; but there was much cloudy weather at about that time also, wholly preventing a watch on several nights, and thus the maximum of the shower may have escaped me, as in other cases, for from the results of a single year’s observation little can be expected to be done in determining durations and intensities of meteor showers, and some of the brightest and most transient will pass altogether unseen. It is only by observation extending over many successive years that so much has already been learned of these features in regard to many of the leading showers. The dates I have given in the list are those within which shooting stars continued to diverge from the radiants mentioned, and do not pretend to show the absolute periods over which the showers extend, though in some cases this is very near the truth. The list does not include some extremely feeble or suspected radiants, supplying 3, 4, or 5 meteors each, which I have held over and will endeavour to confirm another year. 660 shooting stars are included in the 51 radiant points actually specified, which comprised a large proportion of small meteors, the relative magnitude of the aggregate number registered during the nine months being:—

>1st mag. and= 2 <sup>d</sup> or 2 <sup>d</sup>	=1st mag.	=2nd mag.	=3rd mag.	=4th mag.	=5th mag.	and—total.
29	55	150	182	234	116	=766

Many fine meteors (including several fireballs) were seen in August (chiefly Perseids), and in December (chiefly Geminids), but in the spring months and in October they were generally very small, and the great majority 3rd–4th mag. In the list I have given the probable number of shooting stars recorded as belonging to each radiant, as this is an important detail, not only as showing the intensity of the shower, but also the value of the position deduced. I have added a column, indicating the

observed specialities of the meteors of each shower, though, obviously, not much can be done in this respect from a single year's work, but it may lead to something more definite and satisfactory being attempted and followed out in the same direction in future years. The descriptions are not by any means to be held as conclusive (for the materials were often scanty, and sometimes uncertain), but as applying only to those members of the different systems that really came under observation, and, except in regard to the more active showers, they may not have afforded a fair sample of the whole. Moreover, the appearance of a meteor is dependent in a great measure upon the position of the radiant point with respect to the apex of the Earth's way. Again, when near the radiant the path is much foreshortened, and the apparent velocity much below the average of the same shower, and *vice versâ*. A white meteor on the horizon will often look ruddy, etc., but, notwithstanding these difficulties, the special features of certain showers are strongly marked and distinct from those of neighbouring ones, and it is an important element to consider, inasmuch as it frequently occurs that contemporary radiants lie near together (or in the same backward prolongation of a meteor's track), and it is sometimes impossible to accord the true focus, unless such details are noted and taken into the account. In some systems these specialities of appearance or motion are strikingly evident, and serve (almost as unerringly as direction of path) to indicate the real centres of emanation. Thus, as instances of extreme velocity, there are the Polarids (September–October), Gemellids (October–November), Draconids, etc.; and as samples of slow motion, the Aquilids (July–August), the Piscids (September–October), the Geminids (December), etc. In the same column I have also given in a few instances the dates of observed maximum or greatest activity.

I have subjoined a list of the observed paths of 85 bright shooting stars recorded during the nine months. These will be useful to compare with the observations of others who may have seen some of them and can afford materials for the calculation of the heights, etc. The magnitudes given are intended to show the *maximum* brilliancy, and the comparisons are with planets and stars of the 1st mag. I have endeavoured to give the *direction* of the paths with as much accuracy as possible, as this is important in the finding of the true radiants, a column of which I have affixed, indicating them. Some details of motion and appearance are also added, but these are somewhat incomplete, especially those relating to colour. Generally, however, I found the slow meteors more or less ruddy, while the rapid ones appeared almost invariably white. Several fine meteors, apparently from the radiant in *Gemini* (36), belonged to the latter class, while others (of the same system?) were noted very slow and red. This anomaly may perhaps be explained by the assumption of a double contemporary shower in *Gemini*, as in the case of the Perseids and Cassiopeids (August), and the Leonids and Leonids minor (November).

## List of 51 Radiant-Points of Shooting Stars observed during April–December 1876.

No. Jan. 1877.	Date of Observation.	Radiant-Point. R.A. Dec. N.	Name or Position of Shower.	No. of Meteors.	Notes.
1	March 16–April 22	142 49	♄ Ursids	6	Meteors small; rapid; a feeble radiant.
2	April 11–May 21	241 24	♌ Coronids	8	Small; white; rapid; no streaks; accurate.
3	April 11–22	230 38	♐ Boötis	8	Small; not rapid; accurate.
4	April 13–May 19	207 48	♊ Ursids	13	Small; short; rapid; an active shower.
5	April 13–22	194 30	♌ Coma Berenidis	7	Small; max. April 15.
6	{ April 13–22 April 17–May 2	195 2 S. 207 7 S.	♍ Virgo ♍ Virginis	10 5	Rather bright; slow; an active shower. Small; probably same as last with mean = 201° 4° S. 15 meteors.
7	April 14–May	277 57	♏ Draconids	6	Small; short, and very rapid; white.
8	May	221 6 S.	♏ Libra	6	Approximate; a feeble shower.
9	July 16–Aug. 25	330 70	♑ Cepheids	18	Small; white; very rapid; like <i>Draconids</i> (12); max. July 19–20; an active shower.
10	July 16–Aug. 14	18 63	♏ Cassiopeids I.	28	Very bright; rapid; with streaks like <i>Perseids</i> (16); max. July 24; an active shower.
11	July 16–Aug. 25	349 24	♐ Pegasids	8	Very slow; feeble.
12	July 16–Aug. 16	284 57	♏ Draconids	21	Small; white; very rapid; max. July 16–18; an active shower.
13	July 16–25	337 7 S.	♒ Aquarids	4	Bright streaks; rather slow; continued in September.
14	July 16–Sept. 17	298 2	♑ Aquilids	14	Bright; very slow; ruddy; continued in September; a fine shower.

15	{	July 16—Aug. 16	340	42	Lacertids	7	Small; white; rapid; no streaks or trains. } Mean of the 3 showers = $344^{\circ} + 42^{\circ}$ ; 17 meteors July 16—Nov. 20.
		Sept. 16—Oct. 25	346	44	"	6	
		Nov. 8—20	344	42	"	4	
16	{	Aug. 5—12	43	59	Perseids	43	Very bright; rapid; bright streaks; max. Aug. 10; very fine shower.
17		July—Aug.	6	27	$\alpha$ Andromedæ	7	Rapid; fairly accurate; feeble.
18		July—Aug.—Sept. 20	313	41	Cygnids	8	Rapid; white.
19		Sept. 17—Nov. 8	15	11	Piscids	17	Bright; very slow; ruddy; trains; mean of 2 showers; continued in December; active shower.
20	{	Sept. 18—Oct. 21	14	50	Cassiopeïds II.	13	Small; rather slow; active shower; mean = $15^{\circ} + 52^{\circ}$ ; 20 meteors.
	{	Nov. 7—8	17	53	"	7	
21		Sept. 17—Oct. 25	317	57	Cepheids	10	Small; very rapid; white; mean of 2 feeble showers.
22		Sept. 20—Oct. 29	161	84	Polarids	7	Very, very rapid; white; position approximate.
23	{	Sept. 20—Oct. 25	31	37	Triangulum	}	Probably same shower, with mean at $35^{\circ} + 39^{\circ}$ ; feeble.
	{		40	40	$\beta$ Persei	9	
24		Sept. 20—Oct. 25	46	26	Muscids	19	Small; rapid; white; max. Oct. 15; an active shower in October.
25		Oct. 13—Nov. 20	85	33	$\theta$ Aurigids	7	Small; rather slow; ruddy; possibly same as 37.
26		Oct. 13—25	48	71	Camelopardus	7	Small; somewhat slow like <i>Cassiopeïds</i> II.; mean of 2 feeble showers.
27		Oct. 13—Nov. 20	125	47	Lynxids	17	Rapid; white; streaks; max. Oct. 29.
28		Oct. 14—17	38	12	$\mu$ Ceti	5	Very slow; a feeble shower; probably same as <i>Piscids</i> (19).
29		Oct. 14—25	90	58	$\delta$ Aurigæ	6	Bright; rapid; a feeble shower; rather uncertain.



No. Jan. 1877.	Date of Observation.	Radiant-Point. R.A. Dec. N. °	Name or Position of Shower.	No. of Meteors.	Notes.
30	Oct.	358 26	$\alpha$ Andromedæ	7	Bright; slow; approximate.
31	Oct. 17-25	88 17	Orionids	8	Bright, with streaks; max. Oct. 17-19.
32	Oct. 21-29	61 18	Taurids I.	6	Bright; not rapid; sometimes with streaks; max. Nov. 8; a fine active shower; mean of the 3 positions = $60^{\circ} + 19^{\circ}$ ; 25 meteors.
	Nov. 8	58 16	"	8	
	Nov. 19-20	62 22	"	11	
33	Oct. 25—Nov. 20	110 23	Gemillids	11	Small; very, very rapid; max. Oct. 30; quite distinct to No. 36.
34	Nov. 8-20	69 66	H. 17 Camelopardi	8	Small; rather slow; continuation of No. 26; max. about Nov. 19-20, or Dec. 6; an active shower.
	Dec. 4-8	70 67	"	6	
35	Nov. 20-28	78 43	Aurigids	9	Small; rapid; white; max. Dec. 13; mean of the 2 showers $79^{\circ} + 46^{\circ}$ ; 21 meteors.
	Dec. 8-14	79 49	"	12	
36	Nov. 21—Dec. 8	103 31	Geminids	20	Very bright; slow; often ruddy, with streaks; max. Dec. 12; mean of the 2 showers, $106^{\circ} + 32^{\circ}$ ; 44 meteors; a very fine shower.
	Dec. 11-21	109 33	"	24	
37	Nov. 22—Dec. 8	80 23	Taurids II.	20	Bright; very slow; max. Dec. 6; fine shower; new.
38	Nov. 19-20	149 22	Leonids	5	Rapid; white; bright streaks; a feeble and late return of the great shower; max. 1866.
39	Nov. 8—Dec. 13	140 65	$\sigma$ Ursids	16	Rapid; white; mean of 2 showers.
40	Nov. 7-25	299 50	Cygnids	5	A feeble shower.
41	Nov. 20—Dec. 13	155 36	Leonids Minor	26	Bright; rapid; white; with streaks like <i>Leonids</i> (38); a very fine a.m. shower.

42	Nov. 20—Dec. 13	342	65	Cepheus	14	Somewhat slow; new (?); rather uncertain, and perhaps confused with <i>Cassiopeids</i> (20); and <i>Cygnids</i> (40).
43	Nov. 21—Dec. 20	208	43	Ursids	17	Small; short; rather swift; max. Nov. 26; an active shower; new.
44	Nov. 20—Dec. 12	208	71	$\beta$ Ursæ Minoris	11	A feeble shower; new; a.m.
45	Nov. 25—28	212	18	$\alpha$ Boötis	7	Small; feeble; max. Nov. 28; a new a.m. shower.
46	Nov. 25—Dec. 21	148	2	Sextantids	11	Bright; very rapid; white; with streaks like <i>Craterids</i> (47); somewhat feeble; a.m. new.
47	Nov. 25—Dec. 21	165	6 S.	Craterids	11	Bright; very rapid; white, with bright streaks; a fine shower; max. Dec. 21 (?); new; distinct from preceding; a.m.
48	Nov. 25—Dec.	187	37	Canes Venatici	6	Small; rather slow; uncertain, and perhaps confused with Nos. 43 and 50.
49	Nov. 25—Dec. 13	112	13	$\beta$ Canis Minoris	7	A feeble shower.
50	Nov. 27—Dec. 12	179	29	Coma Berenicens	8	Small; short; not rapid, like No. 43; max. Nov. 27; now; a feeble a.m. shower.
51	Dec. 12—21	221	53	Quadrantids (?)	8	Rather slow; white; streaks.

No.	Date. 1876.	Mean Time.		Magnitude.	Path		Length of Path.	No. of Radiant in List.	Notes.
					From R.A. D.N.	To R.A. Dec. N.			
1	April 13	h 10	m 3	1	206 50	213 73	23	6	Slow; no streak.
2	"	10 52		1	251 66	248 50	15	Polaris?	Slow; no streak.
3	14	8 26		1	197 37	226 26	34	Ursa	Very slow, 2½ secs.; rapid at first, then slow, coming almost stationary at the end.
4	"	9 48		α Lyrae	150 12 S.	131 4 S.	21	?	Rather doubtful path.
5	15	8 31		> ♀	90 24	52 31	34	6?	Pear-shaped fireball; rather swift; white; no streak; rather uncertain direction.
6	20	10 45		1	235 10	250 17	15	6	Very slow; in clouds.
7	22	9 58		1	290 43	316 47	19	α Lyrae	Slow; white.
8	"	10 28		1	245 13	256 18	11	6	
9	25	9 51		1	13 83	32 68	16	?	Not rapid.
10	May 8	9 17		> 1	281 40	312 51	24	6 or 8	Slow; no streak.
11	10	10 58		1	278 41	296 56	18	α Ophiuchi	Rather doubtful path.
12	11	9 56		1	236 53	216 64	16	"	
13	July 15	11 5		1	251 49	237 44	11	12	Very rapid; white; no streak.
14	16	10 30		1	240 18	221 20	18	14	Slow; streak.
15	"	11 17		1	260 80	225 67	15	10	Rapid; streak, 2 secs.
16	18	11 20		> 1	211 49	206 18	31	10	Rapid; bright streak.
17	19	10 58		4	346 25	337 12	20	10	Not very rapid; streak 1½ sec.
18	20	11 29		1	341 6	335 8 S.	15	10?	Streak 1½ sec.
19	"	11 42		1	338 32	342 21	11	9	Rapid; no streak.



20	"	11	50	> 4	337	7 S.	346	18	26	Aquarius	Rapid; sparks and streak.
21	21	10	26	♀	306	27	317	49	24	14	Rather slow; streak 2 secs.
22	24	10	39	1	268	79	231	67	15	10	Bright streak.
23	"	10	44	> 1	253	79	225	67	14	10	Bright streak.
24	"	11	28	1	344	11	356	39	30	13	Rather slow; streak.
25	"	11	34	4	38	53	55	39	19	12	No streak.
26	25	10	55	1	276	4	275	5 S.	9	α Lyrae	Rapid; white; no streak.
27	"	11	19	1	326	23	345	31	18	14	Very slow; streak.
28	31	9	43	Sirius	284	10	286	10 S.	20	α Lyrae	Rather swift; no streak; clouds.
29	Aug. 5	10	12	1	62	71	95	69	11	10	
30	"	10	12	4	20	47	8	38	23	16	Bright streak.
31	"	10	40	4	199	54	207	19	35	16	Not very swift.
32	8	10	33	1	44	46	44½	37	9	10	Streak.
33	"	11	20	1	26	23	25	11	12	16	Rapid.
34	"	11	57	4	6	25	356	39	16	Pegasus	Not very rapid; bright streak.
35	10	9	28	> 4	53	79	214	74	27	16	Rapid; streak 2 secs.
36	"	9	54	2 × ♀	85	78	183	68	27	16	Rapid; streak for 5½ minutes, at about 151° + 78°.
37	"	11	59	1	50	20	51	14	6	16	Rapid.
38	"	12	59	4	27	20	23	11	10	16	Rapid.
39	"	13	49	1	101	76	161	71	17	16	Rather uncertain.
40	"	14	28	1	219	84	220	71	13	16	Rapid.
41	"	15	13	1	15	22	9	7	16	16	Rapid.
42	11	10	27	1	315	9	307	3	15	...	Rapid; streak.
43	"	10	38	4	151	69	170	53	19	16	Rapid; streak.

No.	Date. 1876.	Mean Time.		Magnitude.	Path		Length of Path.	No. of Radiant in List.	Notes.
		h	m		From R.A. D.N.	To R.A. Dec. N.			
44	Aug. 11	11	20	> ♀	196 68 ° °	210 47 ° °	22	16	Rapid; streak 1 minute.
45	"	13	50	I	108 62	128 55	12	16	Rapid; no streak.
46	14	11	35	I	212 42	204 36	9	12	Shone out like a star almost stationary at the end.
47	15	9	26	♀	208 25	186 23	20	14	Very slow; pear shaped.
48	21	9	20	I	179 51	171 46	7	12	Rapid; rather doubtful.
49	24	9	20	I	37 64	36 74	10	24	Streak.
50	Sept. 10	8	15	I	40 54	6 60	19	α Aurigæ	Rather slow; bright streak.
51	19	10	14	24	11 1	8½ 2½ S.	5	19	Very short and slow; 2½ secs. near its rad. bright streak 3 minutes.
52	20	9	47	I	22 42	356 43	19	23	Rapid; streak.
53	Oct. 13	10	13	I	64 53	83 55	12	23	Rapid; no streak.
54	14	11	19	24	43 22	30 2 S.	27	29	Rapid; long streak.
55	15	6	17	I	7 24	18 22	10	30	Very, very slow; twilight.
56	21	7	6	I	336 1	329 9 S.	12	30 (?)	Rapid; no streak.
57	"	11	6	I	21 11	25 2	10	30	Slow.
58	Nov. 1	8	35	24	347 18	348 9 S.	28	42	Slow; full moon; rather doubtful.
59	7	8	15	I	88 67	104 65	7	34	Rather slow; streak.
60	8	5	6	> ♀ (?)	236 50	241 35	16	32	Very slow; streak; seen in daylight; uncertain.
61	"	6	35	> I	339 29	289 9	50	32	Rather slow; 3 secs.; streak.
62	"	6	57	1.5	329 30	284 10	46	32	Not swift.

63	"	8	59	1	8	19	346	17	20	32	Streak; 5 secs.
64	9	8	58	1	44	6	32	4 S.	16	32	Doubtful path.
65	20	7	27	1	79	50	103	64	19	32	Not rapid; streak.
66	"	8	37	1	20	10	25	14 S.	25	42	White; rapid; uncertain.
67	25	17	31	> 1	248	52	268	44	16	41	Rapid; white; bright streak.
68	26	16	32	1	145	67	220	59	32	37	Slow; red; 2 maxima.
69	27	16	9	1	159	10 S.	184	18	25	49	Rapid; white.
70	28	17	18	1	179	74	235	67	14	39	Very rapid; white.
71	"	18	5	1	175	34	184	33	8	41	Very rapid.
72	Dec. 6	7	8	1	90	35	96	38	5	37	Very slow; near rad.
73	"	9	35	1	103	5	104	3 S.	8	36	Red; streak.
74	8	10	16	2	118	44	128	48	8	36	Slow; streak 2½ secs.
75	11	11	17	> 1	55	4	45	3 S.	12	36 (?)	Rapid; white.
76	12	6	54	1	119	78	266	76	24	36	Not rapid; streak.
77	"	8	15	less than ♀	106	37	102	43	7	36	Very, very slow; ruddy; streak 10 secs.
78	"	8	47	1	156	52	133	42	18	51	Rapid; white.
79	"	16	2	1	183	41	200	37	14	36 (?)	Rapid; white.
80	"	18	18	2	202	19	218	12	10	36 or 41	Rapid; streak 6°, 7 sec.
81	"	18	34	1	199	13 S.	218	24 S.	21	36	Slow.
82	13	10	58	1	144	12	162	17	17	Monoceros	Slow.
83	19	10	20	> ♀	43	13	24	4	21	36	Slow, 1·5 sec.; cloudy.
84	21	10	31	2	144	33	162	31	16	36	Slow.
5	"	14	53	1	142	28	122	7	27	51	Very rapid, white.